Structural Engineering Lesson Plan/Activity

California Core standards of Education for Science (3-5ETS1-2); Computer Science (6-8.AP.15), Science (MS-ETS1-3) and Career Technical Education Pathways (standards CTE.EA.B.6.0, 6.1, 6.2, 6.3 and 6.4)
Web Page: https://www.spk.usace.army.mil/Media/Engineers-Week/

Intro/Discussion (directed toward teacher/parent as a resource to teach student/child)

1. Ask these questions to start sparking interest and build a conversation:
2. What do you think an engineer does?
3. Did you ever need to solve a problem by creating something new?
4. Why is it important for an engineer to draw a solution before building it?
5. What can you do if a solution to a problem doesn't work the first time?
6. What is the coolest invention you have ever seen?
7. If you could be an engineer, what kinds of projects would you like to work on?

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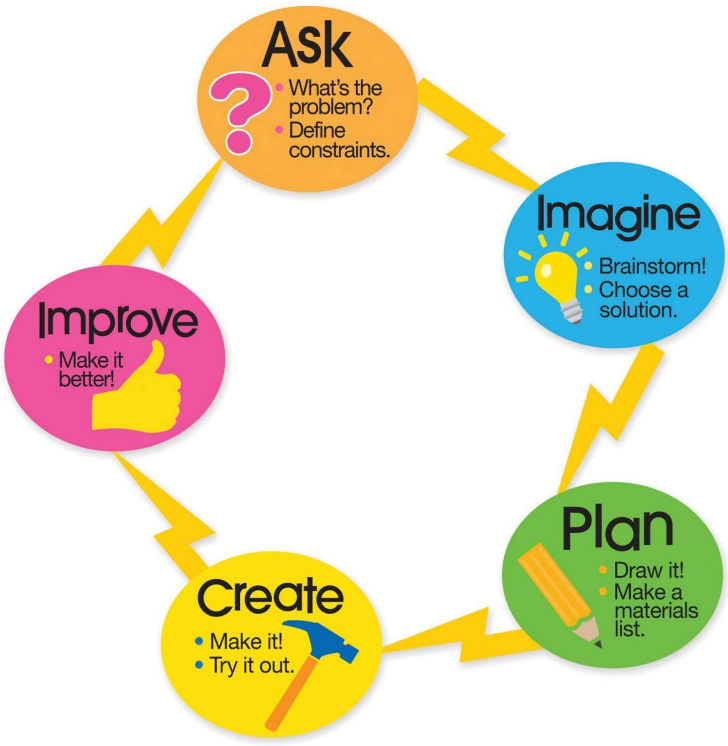
There are a multitude of different types of engineers—from Aerospace Engineers to a Sports Engineers, engineering is a broad term for specialized people that have one major thing in common: the Engineering Design Process. The Engineering Design Process (EDP) is a step-by-step method of solving a problem by creating something tangible with a specific function. That is a fancy way of saying, "this is the way to think like an engineer!"

The Engineering Design Process consists of steps that different groups may label differently. Regardless of what each step in the process is called, the order and content of each step is crucial so that kids come to viable solutions. The depth of understanding of this process will also equip kids with an invaluable method of thinking and tools to use in real life problem solving. The following description of each step in the EDP provides a quick glimpse into what the primary focus is in each part of the process.



The first step in the engineering design process is to **Identify The Problem**. It is crucial that this step not be completed without thorough consideration. Identifying the problem includes discerning what is needed as well as any constraints or rules that must be followed.

Next comes **Brainstorming and Imagination**! Creativity is king here, but it can also be overwhelming for kids to know where to start in coming up with a feasible idea. Encourage them to look at each material available and write out how each material may be useful in solving the problem.

Now for the **Design/Planning** phase! From the list made in the brainstorming step, a design may be drawn showing key components previously identified as important. Labeling each part in their sketch will help them in the next step as well as keep inventory of how much of each material is needed.

Then comes the moment the students have been waiting for – **Build!** From their design sketch, kids can bring their creations to life. Here, they may discover that some materials will not work as they had planned and some changes may be necessary.

Once the designs have been built, **Testing** may begin. This step is where frustration may set-in and many kids become discouraged if their design continues to fail. The key is teaching that failure is an important part of the Engineering Design Process. Failure is what shapes designs to their optimal performance. Because of this truth, failure should be celebrated as an opportunity to make something better!

There is, however, a right way to fail—that is, failure is only positive if learned from and used for improvement. If a design fails during testing, ask the future engineer to write down what went wrong and make notes on how to resolve any issues. Then any design changes must be made before another trial is attempted. This cycle of test/evaluate – **Redesign** – and build may repeat for a little while until success is achieved. If there does not seem to be any progress being made, ask students to observe what is/is not working in other groups' designs. After a successful test, it is helpful for students to make a sketch of their final design for comparison and reflection.

Arguably, the most important part in the engineering design process is the final step—Share the Solution! Every scientific discovery or feat of engineering would be a waste if it weren't shared with the world to glean from its success as well as stories of its failures along the way. Those doing the activity should share their designs with their class, families, or friends and what they learned from any failures.

Video resources

Civil Engineer Video: https://youtu.be/gCbBfWukc1Y

Structural Engineer Video: https://youtu.be/_VJk2u2q-Tk

Activity Below….

STEM ACTIVITY: Cardboard/Paper Towel Roll Building Structure

In this challenge, kids will learn how to use their imagination to design and create a building structure using cardboard and/or paper towel/toilet paper rolls. In engineering, there are a lot of different ways to attach objects together. There are also ways to specify how two objects should fit together, whether they should have a **clearance fit** (some gap) or an **interference** or **press fit** (no gap, objects may need to be forced together with a press, frozen to shrink while fitting, then put in place and allowed to come back to room temperature).

Make it more challenging: Give students a variety of crafting objects to fit with cardboard tubes that they are required to use. They will have to note the dimensions and determine what the best type of fit/attachment is.

Video suggestion: Cardboard attachment video tutorial
https://www.youtube.com/watch?v=P8RRJVOZnSA

Materials Suggested

Structure: Carboard, Paper Towel/Toilet Paper Rolls
Additional Materials: Scissors, Tape, Glue
Optional Materials for more challenge: String, brass fasteners, straws, wire, hole punch, wood skewers

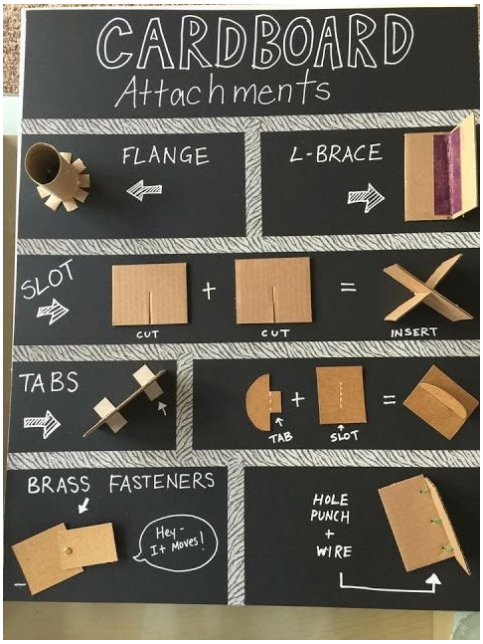
(If wanting to create more of a challenge, be sure to include additional engineering design constraints when adding optional materials)

Engineering Design Constraints

1. The structure must have everything attached securely.
2. The structure must be at least 8 inches long, 8 inches wide, and 18 inches tall.
3. Use at least two methods of attachment (see picture below).
4. Be able to hold up the weight of something equivalent to 2 pounds.

Ideas for additional design constraints

1. Increase size to 12 inches long, 12 inches wide, and 24 inches tall.
2. Use three methods of attachment
3. Hold 3lbs or 4 lbs of weight
4. Must include 3 levels



Engineering Design Process

1. **Identify**: Describe the goal of the challenge in your own words. Include any important design considerations.
2. **Brainstorming**: Now is the time to start thinking about possibilities, be creative!
3. **Design/Imagine**: How will you solve the challenge? Sketch at least one design idea, and label the parts of the design and materials used.
4. **Create:** Time to bring your design to life! Using your design sketch as a starting point, build your solution. Keep in mind that materials may not work as you predicted. Engineers often have to make several modifications to their original design before they are successful.
5. **Test/Evaluate/Improve**: Test your design and record results below. Circle if the challenge was a success. Remember that failure is an important part of the engineering process! After each trial, review the results and make changes to improve your design.

Trial Results of Test Challenge (ie are all constraints successfully addressed)

Trial	Results of Test	Challenge Completed	Ideas for Improvement
		Y/N	
		Y/N	
		Y/N	
		Y/N	
		Y/N	

How many trials were needed for a successful result? _____

Reflect & Share Answer the following questions.

- What challenges did you face during the design process?
- How does this challenge relate to a career in STEM?

Sketch your final Design to showcase with your completed carboard structure.

After Lesson/Activity questions.

- What kinds of things does an engineer do?
- Why is it important for an engineer to test things they create?
- Why is it important for engineers to have a good imagination?
- What are some steps that engineers go through when solving problems?
- What are some examples of problems different types of engineers have solved?
- Why don't engineers get upset when their solution doesn't work?

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Congratulations and thank you for participating in the Science Technology Engineering & Mathematics (STEM), Home Challenge Activity!

Would you enjoy sharing, viewing, and comparing your concept model with other Students and Professional Engineers?

If so, please include a photograph of your finished design and model only and email it to **James.D.Henriksen@usace.army.mil by March 1st**. Photos containing any persons will NOT be posted. We encourage you to include a short description of yourself (name and grade level) AND one thing you learned and/or enjoyed while completing this project. Upon photo submission, the LDP Tier II Team will email you an authentic certificate of participation.

Photos will be posted on the Army Corps of Engineers – Sacramento District's official **"FACEBOOK PAGE".**

We, the Leadership Development Program (LDP), Tier II Team of 2021, hope you have enjoyed this glimpse into what the US Army Corps of Engineers does to ensure the safety, security and day to day life for you and all citizens within these United States of America.